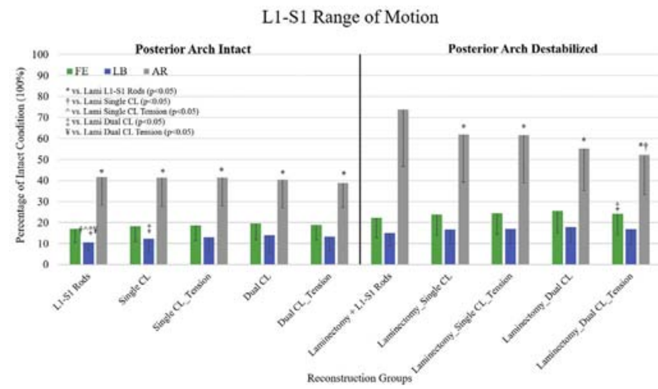
surgical destabilization and reconstruction procedures. While results add value to the concept of placing crosslinks in tension, further studies are necessary to determine the biomechanical and clinical significance.



Disclosures: author 1: none; author 2: none; author 3: none; author 4: none; author 5: none; author 6: royalties=Orthofix

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BRAIN AND SPINE 1 (2021) S1–S124 100075

CORRELATION BETWEEN MECHANICAL PROPERTIES AND POROSITY IN SILICON NITRIDE BIOCERAMIC

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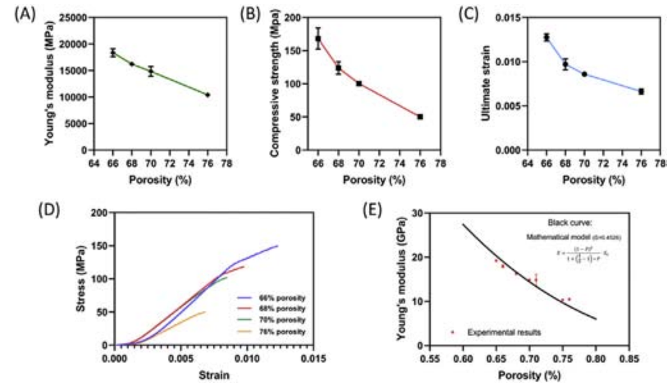
Introduction: Silicon nitride possesses a variety of favorable characteristics and can be specifically designed and fabricated for spinal implants. However, its high Young's modulus may cause stress shielding and lead to bone atrophy. The design of a porous structure provides a possible avenue to reduce the stiffness of implants, but usually at the cost of decreased strength. However, sufficient strength is also required to ensure the safety of the implant. The aim of this study was to investigate the correlation between mechanical properties and porosity in a silicon nitride bioceramic to obtain valuable data for designing optimal porous spinal implants.

Methods: Porous cylindrical silicon nitride scaffolds have been fabricated by SINTX Technologies Inc. The Young's modulus, compressive strength, and ultimate strain of the scaffolds from the different porosity groups were determined using a materials testing machine under quasi-static loading. A mathematical model developed by Nielsen [1] was used to describe the porosity dependence of Young's modulus for porous silicon nitride scaffolds. The shape factor was determined by fitting the model to the measured values. Standard dense silicon nitride bars were also prepared as a control group, and the Young's modulus was determined by the sonic excitation method.

Results: The measured Young's modulus of the dense silicon nitride was 298.45±1.08 GPa, which is significantly higher than the Young's modulus of dense trabecular bone (14.8 GPa (S.D. 1.4)) and cortical bone (20.7 GPa (S.D. 1.9)), both measured ultrasonically in the study of Jae et al. [2]. However, the Young's modulus of silicon nitride samples with 70% porosity was 14.84±0.91 GPa, which is in the range of that of a trabecular bone. The compressive strength was 100.35±3.39 MPa, which is sufficient for load bearing purposes as a substitute for trabecular bone. Moreover, the results of the quasi-static compression test showed that Young's modulus and compressive strength decreased non-linearly as porosity increased. The experimental data was used to fit the mathematical model [1]. A shape factor S=0.4526 was determined.

Conclusion: It is desirable to reduce the Young's modulus for spinal implants to values in the range of natural bone to promote a homogeneous stress transfer between the implant and host bone. Our study shows that altering the porosity of silicon nitride is an efficient way to tailor its stiffness. The good fit with an established model provides a simple method to predict Young's modulus of porous silicon nitride ceramics, which can be utilized in the future design of optimal or even patient-specific porous implants.



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[2] J.Y. Rho, R.B. Ashman, C.H. Turner, J Biomech 26(2) (1993) 111-119.

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BRAIN AND SPINE 1 (2021) S1–S124 100076

DEVELOPMENT AND VALIDATION OF A SUBJECT-SPECIFIC FINITE ELEMENT MODEL OF PATHOLOGICAL LUMBAR SPINE

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The effective prediction of the risk of vertebral fracture is still a challenge in the clinical practice, and it is more demanding if pathologies, such as bone metastases, occur. Several tools were developed in the last decades but frequently they lack in specificity or sensitivity, leaving the prediction based on the orthopaedic's experience. Subject-specific finite element (FE) models based on computed tomography (CT) images are extensively used in the research field and are considered a promising tool to predict vertebral strength in vivo. However, before being used as a reliable tool, the outcomes of FE models must be validated against experimental measurements.

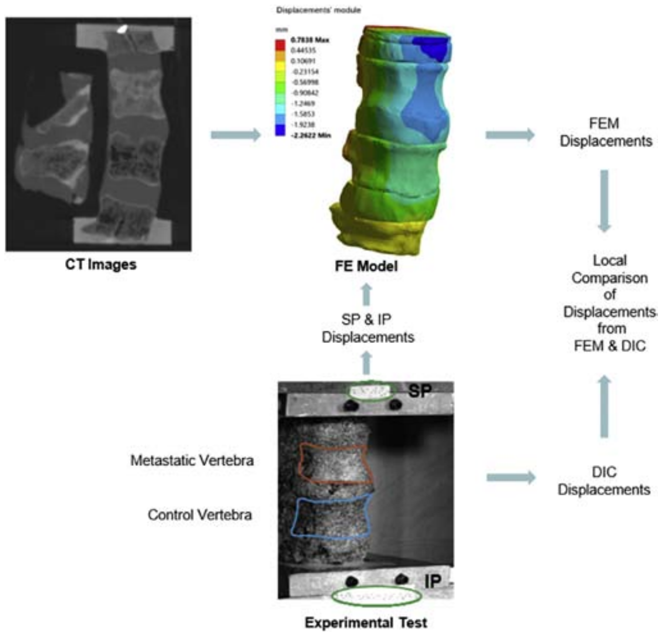
The aim of this work is to define a procedure to develop and validate subject-specific FE models of cadaveric metastatic spine segment comparing the surface displacements predicted by the model against the experimentally measured displacements.

The specimen, consisting in a cadaveric lumbar segment (L1-L4) obtained by an ethically-approved donation program, was scanned with a CT machine, following a clinical protocol.

The specimen was loaded in flexion using a uniaxial testing machine. The full-field displacement maps on L2 and L3 surfaces, and the pots containing L1 and L4 (IP and SP) were measured using a Digital Image Correlation approach.

A FE model, to replicate the experimental test, was developed in Ansys. A 10-node quadratic tetrahedral mesh was generated with max element edge length equal to 2 mm. Subject-specific mechanical properties of the vertebral bodies were mapped on each element using the parameters of the calibration acquisition and a density to elasticity relationship from literature, while population-averaged properties of the intervertebral discs were used. The boundary conditions (BCs) replicated the experimental test: rigid body motions of both the inferior (IP) and superior (SP) pots, obtained by the DIC data, were imposed at the superior and inferior surfaces of the upper and lower vertebral bodies of the model (Fig. 1). A correlation analysis was performed at each node of the middle vertebrae (L2 and L3) of the model, comparing the predicted cartesian components of the displacements against the measured ones.

Preliminary results showed good prediction accuracy on more than 2600 measurement points (R2>0.90) both on the control and metastatic vertebrae. The developed FE modeling strategy resulted promising to predict surface displacement field on human spine segment under realistic loading conditions. This could pave the way to a new clinical application, where the FE models of patients can simulate a large variation of loading conditions on the same spine, in order to identify those cases which could expose the patient to a high risk of fracture.



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BRAIN AND SPINE 1 (2021) S1–S124 100077

ANATOMICAL VARIATIONS OF RIB CAGE ANATOMY WITH AGE AND GENDER: A 3D ANALYSIS IN ERECT POSITION

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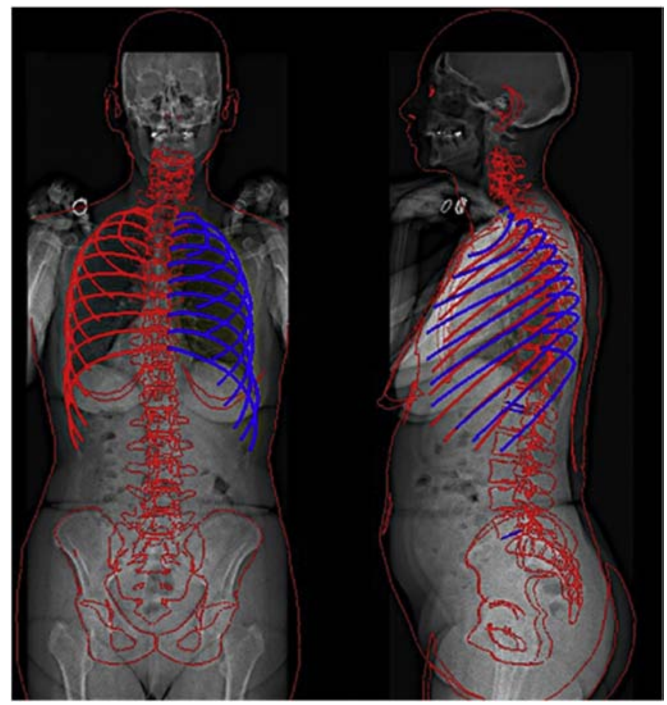
Introduction: Thoracic cage anatomy and its variation need to be further understood as it is linked to spinal anatomy and respiratory function. This study analyzes the anatomical variations of the thoracic cage (TC) with spino-pelvic alignment, age and gender using stereoradiography in erect position.

Methods: This retrospective multicentric study analyzed computed parameters collected from free-standing position biplanar radiographs, among healthy subjects. Collected data were: age, gender, pelvic parameters (Pelvic Incidence (PI), Pelvic Tilt (PT) and Sacral Slope (SS)), T4-T12 Kyphosis (TK), L1-S1 Lordosis (LL), curvilinear spinal length (measured between T1 and L5), global thoracic cage parameters (maximum thickness, maximum width, T1-T10 rib cage volume, mean Spinal Penetration Index (SPI)), rib parameters, computed for each rib from 1 to 10 (3D length, absolute and relative (to the corresponding vertebra) sagittal angles and "umbrella angles", which is the coronal angle between two ribs). The cohort has been divided in two subgroups for gender comparison (growing (8-19) versus mature skeleton (20+)) and into five groups for age study: Children (8-12 years), Adolescents (13-19), Young (20-39), Adults (40-59) and Seniors (60+). Multivariate analysis, was used to ascertain the interactions between gender and rib cage parameters.

Results: 256 subjects were included (140 females, 112 males). Mean age was 34 ± 20.1 years (range: 8 - 83). Male subjects presented larger TC in terms of thickness, width and volume ($p<0.001$). Ribs were longer in male subjects at all levels ($p<0.001$). Female subjects had higher SPI than males ($p<0.001$), as well as higher relative sagittal angles at all rib levels ($p<0.001$). SPI significantly decreased only after 20 years old ($p<0.001$). The four global TC parameters correlated with age, however only thickness and SPI significantly changed after 20 years of age (respectively 0.39 and -0.52, $p<0.001$). During growth, TC thickness also correlated with age (0.47, $p<0.001$). Volume and width only changed during growth (both 0.73, $p<0.001$). Ribs relative sagittal angle showed negative correlation with age in skeletally mature subjects ($p<0.001$). A negative correlation was found between TC Thickness and relative sagittal angles (-0.71, $p<0.001$). Significant correlations were found between TK and Thickness (0.28, $p<0.001$). Conversely, a -0.25 correlation has been exhibited between SPI and TK.

Conclusion: Males have larger thoracic cages in terms of width, thickness, volume and rib length. Females have higher SPI and ribs relative sagittal angles than males. Thoracic cage ages mainly through increasing its antero-posterior diameter, hence augmenting TC volume. TC thickness increases constantly, as well as ribs relative sagittal angles decrease. SPI seems to be more specific of aging as it starts decreasing after adolescence, whereas rib length and TC width grow only during skeletal maturation.



Disclosures: author 1: stock/shareholder=NovaSpine; author 2: none; author 3: grants/research support=, consultant=, stock/shareholder=, royalties=,other financial report=,employee=,none; author 4: none; author 5: none; author 6: none; author 7: grants/research support=, consultant=, stock/shareholder=, royalties=,other financial report=,employee=,none

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BRAIN AND SPINE 1 (2021) S1–S124 100078

SPINOPELVIC MOVEMENT STRATEGIES DURING SIT-TO-STAND IN ADULT SPINAL DEFORMITY

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Introduction: Current evaluation in adult spinal deformity (ASD) did not yet result in effective conservative treatment improving patient functionality (i.e. physiotherapy). The reason might be the static character of radiographic parameters, inherently preventing adequate description of the dynamic functional ability of the patient in daily life. This study aimed for the objectively description of dynamic spinopelvic alignment in ASD during sit-to-stand (STS) compared to healthy controls.

Methods: 42 patients were divided into three deformity groups (ASD 1: decompensated sagittal malalignment, ASD 2: compensated sagittal malalignment, ASD 3: only coronal malalignment) and compared to 18 controls. Subjects were equipped with a spinal marker model during biplanar imaging (EOS Imaging, Paris, France) and motion analysis (Vicon, Oxford Metrics, UK). 3D positions of markers and vertebral bodies were identified on biplanar images to correct marker positions towards the subject-specific anatomy. A polynomial was